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GEOLOGICAL SURVEYS OF OHIO.

But little was known of the geology of Ohio so long as its surface was covered with the primeval forest. Bedded rock, suitable for use as building stone, was found, if at all, by the early settlers in the valleys of the principal streams. In many districts such stone was hauled a dozen miles or more where now as good or better can be found in every mile of the interval. The clearing away of the forest, the drainage of the swamps and the straightening of the channels of the streams have increased the efficiency of the floods to such an extent that scores or hundreds of exposures of rock are now found where a hundred years ago there was but one. The presence of coal in the southeastern quarter of the State was not unknown at an early date ; but it is surprising to find at how few points it was noted by the early occupants of the country, and how completely the most important seams, as we now know them, were concealed from view.

The earliest scientific observations extant on the geology of the State, which I have been able to discover, are to be found in *Silliman's Journal*. In Volume I., 1818, two communications appear from the pen of Caleb Atwater, Esq., of Circleville, one on the Origin of the Prairies and Barrens of the West, including northern Ohio, and the second on the Scenery, Geology, Mineralogy, etc., of Belmont County.

Between 1820 and 1835 numerous notes and papers appeared in the same journal on the geology of Ohio, some of which were of extreme interest and value. Three articles in particular, written by Dr. S. P. Hildreth, of Marietta, and published respectively in 1826, 1828 and 1832, deserve special mention as by far the best statements that had appeared up to this date on the geological order of the Coal Measures of the State. Many important facts concerning their stratigraphy and structure were clearly recognized and stated, and very interesting information was furnished

as the facts and conditions of the occurrence of salt water, petroleum and natural gas in the Muskingum Valley and in southern Ohio, generally.

The discovery of cannel coal for the first time in the United States was announced in a letter written by Hon. Benjamin Tappan, afterwards United States Senator from Ohio, to the *American Journal of Science* (previously Silliman's), published in Volume 18, 1830. The coal was found near Cambridge, Guernsey county, and came from a seam that has been found to be altogether worthless, while valuable cannel has since been discovered in many other localities in this State, as well as elsewhere in the country, but the discovery named above awakened great interest at the time.

The subject of state geological surveys was being considered about this time, and some of the articles already referred to were written in the apparent interest of such a survey of Ohio.

The first official suggestion of a geological survey of Ohio is to be found in the annual message of Gov. Robert Lucas, to the Legislature of the State, dated December 8, 1835. Hon. A. G. Thurman was private secretary of the Governor, and was credited by those conversant with the facts with the probable authorship of this portion of the message. The Governor's recommendations, which were very earnest and cordial, were referred to a select committee of the State Senate, who subsequently reported a joint resolution appointing Dr. S. P. Hildreth, John Locke, J. S. Riddell and Mr. I. A. Lapham a committee to report to the next Legislature the best method of obtaining "a complete geological survey of the State" and an estimate of the probable cost of the same. The committee made an elaborate report in due time, and, in accordance with its recommendations, an act was passed by the next Legislature, viz., in March, 1837, providing for "a complete and detailed geological survey of the State," which should also include the chemical analysis of soils, ores, marls, saline and other mineral waters, the construction of a geological map of the State, and the collection of the organic remains of the various formations and the supplying of sets of

the same to the leading institutions of learning of Ohio. In their estimate of expenses, the committee recommended an annual appropriation of twelve thousand dollars (\$12,000) for four years as adequate to cover the work above outlined. The report further recommended that for the prosecution of the survey there should be appointed "a skilled geologist" with not more than four assistants, one of whom was expected to be a naturalist. It was also recommended that a topographical engineer should be added to the corps.

In pursuance of this action the Governor appointed Prof. W.W. Mather principal geologist and Drs. S. P. Hildreth and John Locke and Professors J. P. Kirtland and C. Briggs, Jr., as assistants, and Col. Charles Whittlesey as topographical engineer. Professor Mather was a graduate of West Point and was, at this time, engaged in the geological survey of New York, having charge of the work in the southeastern portion of that State, an experience which brought him great prestige in Ohio. Dr. Hildreth was unable to continue in the active work of the survey by reason of the infirmities of age, and retired, after a service of a few months, during the summer of 1837. Col. J. W. Foster, of Zanesville, was added to the corps during the first summer. Prof. J. P. Kirtland was the naturalist of the survey, and it is safe to say no man in the State was so well fitted for this place as he. Dr. John Locke, an Englishman by birth, and at the time professor of chemistry in one of the medical colleges of Cincinnati, brought to the service of the State good powers of observation and sound scientific training, though it does not appear that before this time he had devoted special attention to geology proper. Col. Whittlesey was, like Mather, a graduate of West Point, and had been connected for a long time with the army. While in this service he had had opportunity to make important geological explorations around the south shores of Lake Superior. He was, in fact, one of the first to report upon the mineral wealth of the now famous districts of Marquette and Keweenaw Point. Professor Charles Briggs, Jr., was a resident of Massachusetts, but had been specially trained in the geology that was known at this time. He

was a modest, unpretending man, but very clear and decided in his opinions and judgments on the geological facts with which he had to deal.

The first survey had thus brought together some of the best scientific talent and training of the State. Its work was begun in 1837, but so late in the season as to preclude extensive investigations. Still, a report of much value and interest was furnished to the Governor in December of that year, and issued by the State early in 1838 under the designation, "First Annual Report of the Geological Survey of the State of Ohio, by W. W. Mather, Principal Geologist, and the several Assistants." It consisted of 134 pages, and contained reports from Professor Mather, Drs. Hildreth and Kirtland, Professor Briggs and Col. Whittlesey. Professor Mather gave special attention to the coal of the State, endeavoring to convince his readers of its practical value and comparing it with charcoal in iron manufacture. He also discussed our native ores with reference to the iron supply of the State, and called attention to the soils of Ohio. The services of a geological survey to agriculture had been strongly insisted on, in the discussions leading to the organization. Dr. Hildreth also discussed the Coal Measures of Ohio, and pointed out particularly some of the leading stratigraphical elements in the series. He also discussed at some length the sources of salt that were known in the State. Professor Kirtland pointed out the advantages to be derived from botanical and zoölogical knowledge, calling special attention to the possible medicinal properties of our native plants. Professor Briggs gave the results of a reconnaissance of the country between the Hocking and Scioto rivers, in which, among other things, he pointed out the geological order of what we now know as the Subcarboniferous System. Col. Whittlesey's report was confined to questions pertaining to the mapping of Ohio.

The next summer, viz., that of 1838, found all the members of the geological corps promptly in the field, and busy, each with the task that had been assigned to him. A chemical laboratory had been equipped by Dr. Mather, and analysis of

minerals and soils was begun by him. This year proved to be the last of the organization, and if this fact had been foreseen a somewhat different direction would undoubtedly have been given to the work of the corps. But as it was, the time was turned to good account. The second annual report, made to the Governor in December, 1838, consisted of 286 pages, and comprises papers from Prof. W. W. Mather, Col. C. Whittlesey, Col. J. W. Foster, Prof. C. Briggs, Jr., Drs. J. P. Kirtland and John Locke.

Dr. Mather's report gives the results of a reconnoissance, extended to all the principal divisions of the State, and that gave apparently for the first time a clear view of the entire geological column of Ohio. He also continued the discussion of the soils of the State, to which he had referred in his previous report, and published the system of analysis which was to be applied to the coals and ores of the State. Colonel Whittlesey confined himself mainly to the topography of the State, but discussing at some length the variation of the magnetic needle and giving a general section from Cleveland across the Western Reserve. The most important part of his report was the determination of the dip of the strata in central and southern Ohio. Colonel Foster described the geology of Muskingum and Licking counties and the adjacent regions. Professor Briggs' report covered a brief examination of very distinct districts of the State, viz., Wood and Crawford counties in the north, Athens and Hocking in the south, and Tuscarawas in the central portion of the State. The most valuable part of his report pertains to the Coal Measures, the order of which was coming to be quite clearly seen. Professor Kirtland published a report of great value on the zoölogy of Ohio, which is still regarded with interest by all students in this field. Dr. John Locke's geological report on the formations of southwestern Ohio and particularly of Adams county, Ohio, is a paper of great interest and permanent value.

The financial stress that began to overspread the entire country in 1837 was the principal cause of the abrupt discon-

tinuance of the geological survey at the close of 1838. The demand for economy in the State administration was urgent, and the expenditure in scientific work, small though it was, was naturally the first to be cut off.

Probably there was some reaction from the extravagant claims that had been made as to the immediate practical results of the survey, and there was also a measure of criticism directed against certain members of the corps. These facts may have had some influence upon the action of the Legislature.

Up to the close of 1838 there had been expended \$16,000 in field work, and eleven counties had been reported upon. The State had also made a small outlay in the publication of the reports. Professor Mather's estimate of the amount required to complete the survey was, at this time, \$50,000.

As to the valuable results of this work there can be no question. The State never received larger returns from any other equal expenditure than from the \$16,000 used in the first geological survey. The increase of wealth in a single county, through the development of mining industries, largely based on the work of the survey, was asserted to be many times more than the entire expenditure which the State had made in its support.

The most important points established in its brief duration were the following, viz.:

1. The oldest rocks of the State are the so-called blue limestone formation of southwestern Ohio.

2. The newest bedded rocks of our column are the Coal Measures of southeastern Ohio.

3. A very gentle southeasterly or southerly dip prevails throughout Ohio, a proper understanding of which renders all its stratigraphy intelligible.

4. Some interesting notes on Pleistocene and Paleozoic paleontology were introduced into the several reports. Colonel Foster, for example, gives the original description in his report of 1837 of *Castoroides ohioensis* (2d Rept., p. 30). Professor Briggs furnishes interesting data as to the *Mastodon* remains

found at Bucyrus (2d Rept., p. 127). Doctor Locke gave a restoration of *Asaphus megistos* (2d Rept., p. 247), and many valuable references to fossiliferous strata and good localities for collecting fossils are to be found in the several reports.

5. Ohio archæology received more or less attention in many of the reports. A decided impulse was given to the study by the work of the survey. Doctor Locke gives a good account, accompanied by a map, of Fort Hill, Highland county.

The two reports of the first survey were limited to a few thousand copies each. The volumes are eagerly sought for at the present time, and command a good price whenever found in the market.

The discontinuance of the survey was a source of regret and mortification to the more intelligent citizens of the State, and efforts presently began to be made looking to its revival and to a completion of its work. It became quite the fashion with successive governors to call attention to the great desirability of prosecuting the survey, and bills were introduced into successive legislatures having this end in view. One such bill was introduced by Gen. J. A. Garfield, while a member of the State Senate in 1860. Nothing came of these efforts, however, until the legislative session of 1869. At that time, inspired by the cordial recommendation and aided by the hearty coöperation of Gov. R. B. Hayes, a bill was passed ordering a geological survey of the State on the lines that the present state of the science demanded. The law authorizing the survey was, before passage, approved, in most of its details at least, by several of the leading geologists of the State, and particularly by Dr. J. S. Newberry, who was subsequently put in charge of the work thus inaugurated.

The support of the agricultural interest of the State was again invoked in behalf of the geological survey, and the unwarranted expectations of 1837 were again encouraged, of large and immediately valuable results to be derived from the analyses of soils and mineral fertilizers. This interest found expression in the requirement of the survey, that one of the

three assistants should be a "skillful analytical and agricultural chemist."

By the organic law the survey was to be completed in three years from the time of its organization, but, it may be added, that a longer tenure was anticipated by the friends of the survey, both in and out of the Legislature. Governor Hayes appointed Prof. J. S. Newberry Chief Geologist, Professors E. B. Andrews and Edward Orton, assistants in geology, and Hon. J. H. Klippart, assistant in agriculture. Mr. Klippart had been for a number of years secretary of the State Board of Agriculture, and was one of the most conspicuous exponents of scientific agriculture in the State at this time. His connection with the survey lasted but a year or two, and his only report is one that appears in the Report of Progress for 1870. Prof. T. G. Wormley, a distinguished chemist, was made analyst of the survey, and a number of local assistants were brought into the field, some of whom began their field work here. In the list of local assistants may be found the names of geologists that have since become distinguished, such as R. D. Irving, Henry Newton, G. K. Gilbert, Andrew Sherwood, W. B. Potter, J. J. Stevenson, and N. H. Winchell.

Professor Newberry was, at the time of his appointment, professor of geology in the School of Mines of Columbia College, New York. This position was an important and permanent one, and he did not feel that it was wise to resign it for an office the tenure of which was not only uncertain, but which must be short at the best. He therefore undertook to carry on the duties of both offices, making compensation to the State for such time as was used in the New York professorship by the employment of assistants at his own charges.

The arrangement proved, in some respects, unfortunate. If Professor Newberry had been able to devote all his time and energy, even for three or four years, to the survey he would have found plain sailing and could have had everything from the legislature which he could reasonably ask, for the feeling of the State was thoroughly favorable to the survey at the outset. But the

non-resident feature of the Chief Geologist's appointment exposed him to constant criticism and attack. His absence from the State during at least half the year, while the Legislature was in session and while laws in regard to the survey were in process of enactment, was the cause of numerous mistakes, particularly in the publication and distribution of the reports. It was undoubtedly this feature of the survey that led to its premature suspension.

Of Dr. Newberry's ability as an all-round geologist nothing now needs to be said. Active and thoroughly trained in field work, a brilliant and sagacious paleontologist, alive to all the demands of the economic interests involved, of the widest opportunities for observation and study, capable at once of minute observation and broad generalization, and master at the same time of a style that was a model in respect to simplicity, lucidity and elegance, he was easily the foremost geologist that Ohio has produced. Admirable as is his best work in the survey reports, many of his friends feel that he has left nothing that adequately and fully represents his great ability as a geologist.

It is unnecessary to describe in detail the contents of the various reports of the survey. A list of all its publications will be found at the end of the present paper.

Professor Newberry's original plan was a comprehensive one. He aimed to cover the entire stratigraphy and paleontology of the State in a series of parallel reports, and at the same time he proposed to meet the demands of the people for practical guidance in dealing with their great mineral staples by the preparation of a volume on economic geology proper. In this last work he was from the first deeply interested. His plan also contemplated a fourth volume, to be entitled "Agriculture, Botany, and Zoölogy."

The fortunes of the second survey must be briefly traced. At the end of the three years assigned for its completion, not more than half the counties of the State had been reported upon; but no strenuous objections were made to its continuance, even with increased appropriations, for several succeeding years. In

1873, the first of the so-called final volumes of the survey was published. As already noted, the volume was planned to appear in two parts, one on geology proper, and embracing as many of the county reports as practicable, and the second part to be devoted to paleontology. For the preparation of this last named volume, the service of the distinguished paleontologist, F. B. Meek, had been secured. The so-called parts of Volume I. differ in size and quality of paper, through an unfortunate oversight and miscalculation of the Chief Geologist. An edition of five thousand copies was recommended by the Chief Geologist. The Governor expressed himself in favor of twice this number and the State Legislature authorized an edition of twenty thousand copies, the cost of the publication of which exceeded \$80,000. The plates alone of the paleontological part cost \$34,000.

Volume II., also published in two parts, followed in the next year, viz., 1874. The inequality in the size of the two parts that was introduced, as before explained, by an oversight in Volume I., was continued in Volume II., as the result of a choice between evils. When these two volumes had been published, it was found that the local reports of the counties would demand another volume, and consequently the Legislature extended the life of the survey through 1874 and made provisions for the preparation of Volume III., also in two parts, viz.: Geology and Paleontology. The first part, Geology, was published in 1878, and in it the remainder of the county reports found place. It was announced at that time that the corresponding part on Paleontology would be in readiness for presentation to the Legislature in the succeeding winter.

But the State was beginning to experience a financial pressure from which it has never since emerged, and the legislatures of the next succeeding years found it impracticable to undertake the large outlays (\$50,000 or more) required for the paleontological part of Volume III., although a considerable outlay had already been made in its preparation. A principal section of the paleontology prepared for this volume was held in manuscript

for several years by its author, Professor R. P. Whitfield, and was then published with the consent of Professor Newberry, in the annals of the New York Academy of Science.

There now remained to be prepared and published two of the volumes embraced in the original plan of the Chief Geologist, viz., the volume on Agriculture, Botany, and Zoölogy, designated Volume III., and that on Economic Geology, designated Volume IV. The first of these, which it was now necessary to call Volume IV., was published in 1882 with a title abbreviated from the original plan, and which the facts of the case required to be still further shortened. No special report had been prepared upon the subject of Agriculture, though more or less material bearing upon this subject is to be found in the separate county reports, and, by what has proved to have been a fortunate accident, the manuscript of the botanical list which had been prepared was mislaid and could not be found in time for the printer. The volume, therefore, is entirely confined to the subject of Zoölogy, and, even in this, only the leading divisions of the animal life of the State are included. The volume that was to be devoted to "Agriculture, Botany, and Zoölogy," and which appears under the title *Zoölogy and Botany*, thus turned out to be a report on the Vertebrates of the State. Dr. Wheaton's list of the birds of Ohio may, however, be noticed as especially complete and authoritative. Professor Newberry had by this time virtually withdrawn from actual connection with the survey, being hopeless of securing the appropriations necessary for the execution of his plans. In 1882, however, the Legislature, which looked with special interest to the volume on Economic Geology, made provision for its publication, but put the work into my charge, Professor Newberry turning over such matter to me as he had accumulated for this purpose. In 1884, the long-delayed volume, now entitled "*Volume V., Economic Geology*," was issued.

Just at this time the remarkable discoveries of gas and oil in the Trenton limestone of northwestern Ohio were in progress, and were awakening a greater interest in geological questions

throughout the State than there had ever been before. The Legislature was, therefore, easily persuaded to extend the investigations on the economic geology of the State so as to include these recent discoveries. As a result, a "Preliminary Report on Petroleum and Inflammable Gas" was published in 1886, and in 1888 the completed volume, entitled Volume VI., *Economic Geology*, was issued.

The work of the second survey was thus being gradually merged in the work of a new organization; and, in 1889, formal provision was made for carrying on geological work henceforth on a new basis, which may be called the Third Geological Survey of Ohio. Continuous work on a small scale was provided for, or rather, it was made possible for the State Geologist to keep the track of such development as was going forward and to present the facts in annual reports. The first report under this plan was published in 1890, and is entitled "First Annual Report, Third Organization." Before the second report was due, I was disabled by illness to such an extent that I could no longer carry on the active duties of State Geologist. Considerable material had, however, accumulated in my hands during the preceding year, and there were also several unfulfilled promises and obligations of the Second Geological Survey which it was now found possible to execute. Accordingly there has been printed, and is now in the binder's hands, a volume entitled Volume VII., the first part of which is devoted to *Economic Geology*, and which may be considered the equivalent of the second and third annual reports, and the second part of which is mainly occupied with the fulfillment of pledges to the State made by the Second Geological Survey. This part contains a chapter on the *Archæology* of Ohio, which was repeatedly promised by Dr. Newberry, and also the "Botany" mentioned above, viz., a list of the plants of the State, immensely superior to the list that was lost ten years ago; and also two chapters on *Paleontology* which were prepared for Volume III., but which, as will be remembered, the Legislature had refused or failed to publish. Several other chapters in the same general line have

been added to the volume. A small edition of the first part of this volume (economic) was issued separately in December, 1893, but it is also included in the volume that is now in the binder's hands.

Among the principal results thus far obtained in the investigation of the geology of the State at the public expense the following may be named:

1. The order, mineral composition and thickness of the leading elements of our scale have been determined, and their outcrops have been mapped with all needful accuracy.

2. The salient features of the geological structure of the State have been brought clearly to light.

3. The paleontology of the State, while it has not been treated systematically or symmetrically, has still received a considerable measure of attention and expenditure. Hall, Meek, Whitfield, Newberry, and Cope have made contributions of great value to our knowledge of the fossils of our series.

4. A great deal has been done in the interests of our economic geology. Chemical analysis has been applied to our limestones, cement rocks, clays and building stones, by no means exhaustively, but still fully enough to furnish safe, practical guidance to our people in every section of the State. But it is to the coal fields of Ohio that the largest measure of service has been rendered. The several seams have been carefully mapped so that the areas of each above drainage are known (Vol. VII.), the order of the seams has been definitely settled with a few unimportant exceptions, and correlations have been established with the Coal Measures of Pennsylvania, Kentucky, and West Virginia. The analyses of our coals have been made on a system that renders the figures fairly representative, and they accordingly command universal confidence in the markets of the country. The mode of occurrence of oil, gas, and salt water in the State has been carefully studied, and the search for these elements of mineral wealth has been aided and rationalized thereby, to some extent.

As to what remains to be done, it is not necessary to speak.

Every road in science leads to the end of the world, and the further we advance, the deeper the problems that arise.

As to the expenditures, by which all this work has been accomplished, exact figures cannot be furnished for the reason that the publication of the various reports has been made by the State printer, and in many instances the several items of expense—paper, printing, binding—have been included in general appropriations, from which they could be separated only with difficulty. The amounts belonging here are not large. For the later reports, full provision for publication has been made in the survey appropriations.

First Survey, 1837-8,	-	-	-	\$16,000.00
Expenses attending the same, cost of publication not included,	-	-	-	700.00
Second Survey, 1869-1890,	-	-	-	280,000.00
Cost of publication mainly included.				
Third Survey, 1890-1894,	-	-	-	11,000.00
Cost of publication mainly included.				
				<hr/> \$307,700.00

PUBLICATIONS OF THE GEOLOGICAL SURVEYS OF OHIO.

FIRST SURVEY.	DATE.	NO. PAGES.	NO. COPIES.	GEOLOGIST IN CHARGE.
First Annual Report.	1838	134	6,000	Mather.
Second Annual Report.	1838	286	6,000	"
SECOND SURVEY.				
Report of Progress.	1869	176	14,500	Newberry.
Report of Progress.	1870	568	14,500	"
Report of Progress.	1871	3	300	"
Geology of Ohio, Vol. I.				
Part I.	1873	680	20,000	"
Part II.	1873	{ 401 49 plates	20,000	"
Geology of Ohio, Vol. II.				
Part I.	1874	701	20,000	"
Part II.	1875	{ 431 59 plates	20,000	"
Geology of Ohio, Vol. III.				
Part I.	1878	958	20,000	"
Geological Atlas.				
Scale 4ms=1inch.	1879		5,000	"
Geology of Ohio, Vol. IV.				
Zoölogy and Botany.	1882	1,070	20,000	"

Geology of Ohio, Vol. V.				
Economic.	1884	1,124	10,000	Orton.
Preliminary Report on				
Petroleum and Gas.	1886	76	2,500	"
Geology of Ohio, Vol. VI.	1888	831	15,000	"
THIRD SURVEY.				
First Annual Report.	1890	323	10,000	"
Geology of Ohio, Vol. VII.				
Part I.	1893	290	2,500	"
Geology of Ohio, Vol. VII.				
Parts I. and II.	1894	{ 990 55 plates	7,500	"

Maps, plates of sections, etc., accompany many of the volumes.

The disposition of the reports has been made almost exclusively by the State Legislature, the members of each General Assembly dividing among themselves for gratuitous distribution the full edition of the volume or volumes of which they had authorized the publication. Not the slightest reference was had to the maintenance of complete sets of the reports. It is scarcely credible that after such large outlays in publication, the volumes should have been scattered in this reckless way. By attention at the times of issue of the several volumes, those specially interested were generally able to complete their sets. Of the later volumes copies have been left on sale, at cost of publication, in the hands of the Secretary of State. He is the only State officer who is able to supply any of the volumes. The reports find their way, however, to bookstores and, owing to the increasing interest of the last few years, hundreds of sets have been thus completed.

EDWARD ORTON.